3.1 FLIGHT PATH

ESAMS uses internally-generated target flight paths, ones developed with the Bluemax Flight Path Generator, or ones constructed from test data. The internal flight path generator develops either straight and level target trajectories or reactive maneuvers based on estimated time-to-intercept and direction of missile approach.

Bluemax is a flight path generator that incorporates the aerodynamic and propulsion characteristics of specific aircraft. The simulation is controlled by flight path segments constructed in much the same manner as a pilot would develop waypoints or by interactive user inputs. Based on commanded heading and altitude changes, the aircraft pitches and rolls to attain the desired states. Thus, Bluemax develops trajectories consistent with specific aircraft's capabilities.

Flight path data can also be input to ESAMS from range test measuring systems from the proper format. Data requirements for target position and orientation are shown Table 3.1-1. The model requires position coordinates (x, y, z), velocities (xdot, ydot, zdot), and orientation (roll, pitch, yaw). Accelerations (and velocities) can be derived if they are not available in the test data.

TABLE 3.1-1. Data Requirements.

Data Item		Accuracy	Sample Rate	Comments
1.1.1	Target X-position	±5 m	10 Hz	Latitude and longitude
1.1.2	Target Y-position	±5 m	10 Hz	required for ALARM
1.1.3	Target Z-position	±5 m	10 Hz	and ESAMS.
1.1.4	Target X-velocity	±5 m/s	10 Hz	Coarser sampling could
1.1.5	Target Y-velocity	±5 m/s	10 Hz	be used for some test
1.1.6	Target Z-velocity	±5 m/s	10 Hz	cases.
1.1.7	Target X-acceleration	±1 m/s2	10 Hz	Acceleration can be
1.1.8	Target Y-acceleration	±1 m/s2	10 Hz	derived from velocities
1.1.9	Target Z-acceleration	±1 m/s2	10 Hz	and times.
1.1.10	Target pitch	±1 deg	10 Hz	
1.1.11	Target roll	±1 deg	10 Hz	
1.1.12	Target yaw	±1 deg	10 Hz	

3.1.1 Objectives and Procedures

This sensitivity analysis for the flight path FE examines the error inherent in the ESAMS approximation of target position via linear interpolation between flight paths points to compute target locations at times required by the model. Potential errors will be maximized in turns. For a turn with constant radius (as shown in Figure 3.1-1), where $R = v^2/a$, v is the speed and a is the magnitude of centripetal acceleration, the angle between flight path points (θ) is:

$$\theta = 2\pi \, \Delta t / T \qquad [3.1\text{-}1]$$

where T is the period of the (circular) orbit and Δt is the time between flight path points:

$$T = 2\pi R/v = 2\pi v/a \qquad [3.1\text{-}2]$$

Hence:

$$\theta = a\,\Delta t/v \qquad [3.1\text{-}3]$$

The maximum error (which occurs at 1/2 θ) is given by the following:

$$\varepsilon = R - \hat{R} \qquad [3.1\text{-}4]$$

$$\hat{R} = R\cos(\theta); \theta < a\Delta t / v \qquad [3.1\text{-}5]$$

$$\varepsilon_{max} = v^2 / a[1 - \cos(a\,\Delta t / 2v)] \qquad [3.1\text{-}6]$$

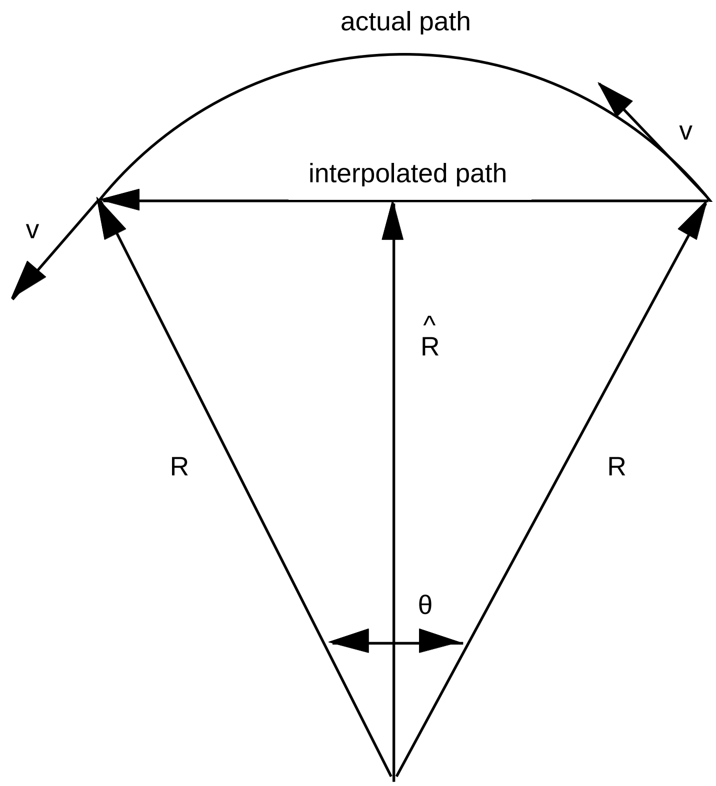

FIGURE 3.1-1. Flight Path Error.

3.1.2 Results

Figure 3.1-2 shows the maximum range error as a function of flight path sample rate and centripetal acceleration (in gees). In order to achieve errors less than a few meters for 6 gees requires an interval of less than 0.5 sec. This requirement should not pose a problem for data collection during testing with maneuvering targets where sample rates of 10 Hz or higher are common.

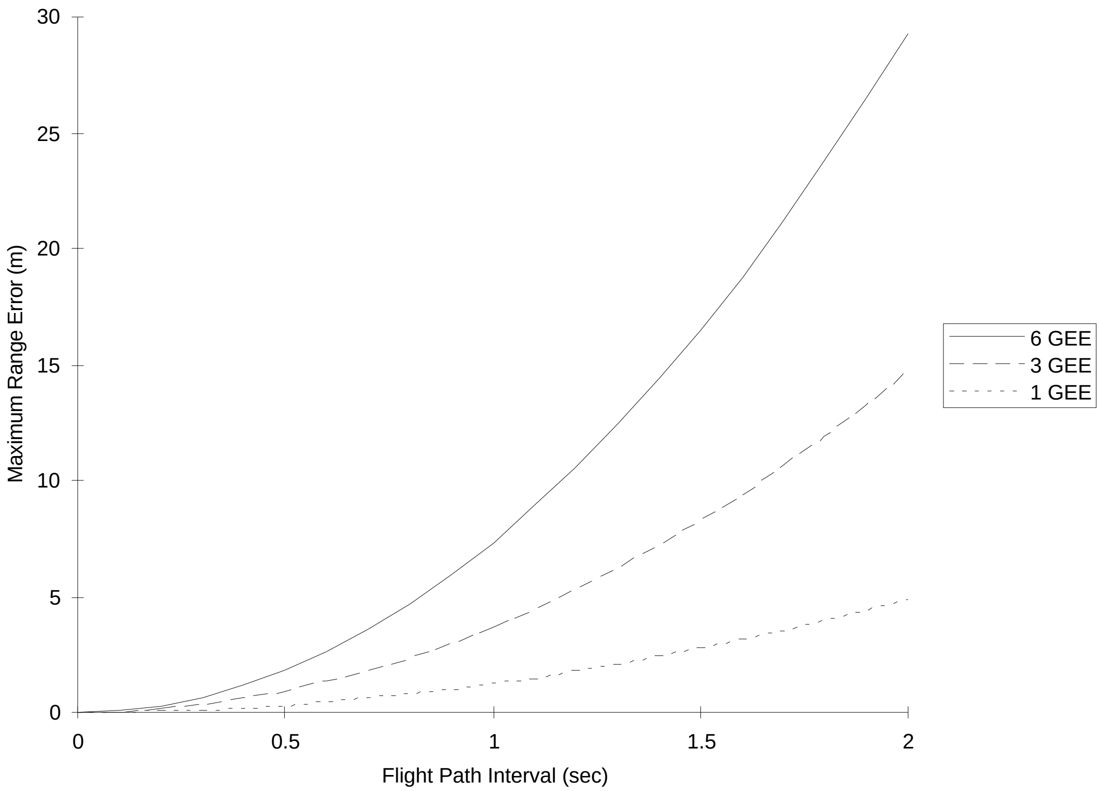

FIGURE 3.1-2. Flight Path Error Sensitivity.

3.1.3 Conclusions

Range error due to linear interpolation can be minimized by increased data rates. Positional errors in the input data; however, will be propagated through the model. Accuracy of target position will exhibit different sensitivities according to particular types of tracking radars, so the ±5m requirements (table 3.1-1) reflects what is feasible as opposed to what would be desired.